The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Signed

Dated 11 April 2003

Patents Form 1/77

Patents Act 1977
(Rule 16)

THE PATENT OFFICE
L
28 MAR 2002
LONDON

The Patent Office

30MAR02 E707601-9 D02955
P01/7700 0.00-0207466.4

1/77

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1.	Your reference	1/PP32609GB
2.	Patent application number *(The Patent Office will fill in this part)*	0207466.4 28 MAR 2002
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)* 08058133001 Patents ADP number *(if you know it)* If the applicant is a corporate body, give the country/state of its incorporation	KIDDE PLC Mathisen Way Colnbrook Slough, Berkshire SL3 0HB U.K.
4.	Title of the invention	FIRE AND EXPLOSION SUPPRESSION
5.	Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* Patents ADP number *(if you know it)*	MATHISEN & MACARA The Coach House 6-8 Swakeleys Road Ickenham, Uxbridge UB10 8BZ 1594001 08188245001
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority application number *(if you know it)* / Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, ~~give the number and the filing date of~~ the earlier application	Number of earlier application / Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	10
Claim *(s)*	6
Abstract	1 DML
Drawing *(s)*	4 +4

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	4
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature MATHISEN & MACARA Date 27 March 200

12. Name and daytime telephone number of person to contact in the United Kingdom: MR D.M. FOSTER (01895 678331)

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) ~~If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.~~

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

FIRE AND EXPLOSION SUPPRESSION

The invention relates to fire and explosion suppression. Embodiments of the invention, to be described below by way of example only, use a mist of a liquid extinguishant, such as water, as the suppression agent.

According to the invention, there is provided a fire and explosion suppression system, comprising a source of pressurised liquid extinguishing agent, a source of a pressurised inert gas, mist producing means connected to receive a flow of the liquid extinguishing agent to produce a mist therefrom, mixing means for mixing the already-produced mist into a flow of the pressurised inert gas to produce a discharge in the form of a two-phase mixture comprising a suspension of droplets of the mist in the pressurised inert gas, and control means for controlling the ratio of the mass flow rate of the liquid extinguishing agent to the mass flow rate of the pressurised gas towards such a value as to tend to produce a desired droplet size distribution in and for substantially the duration of the discharge.

According to the invention, there is further provided a fire and explosion suppression method, in which a mist of a liquid extinguishing agent is produced from a flow of the liquid extinguishing agent and is mixed into a flow of pressurised inert gas to produce a discharge in the form of a two-phase mixture comprising a suspension of droplets of the mist in the pressurised inert gas, including the step of controlling the ratio of the mass

flow rate of the liquid extinguishing agent to the mass flow rate of the pressurised gas towards such a value as to tend to produce a desired droplet size distribution in and for substantially the duration of the discharge.

Fire and explosion suppression systems and methods according to the invention, employing a mist of a liquid extinguishing agent, will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a schematic diagram of one of the systems;

Figure 2 is a graph for explaining the operation of the system of Figure 1; and

Figure 3 shows a modification of the system of Figure 1;

Figure 4 shows another of the systems.

Referring to Figure 1, the system has a vessel 5 storing water. The vessel 5 is connected to an input of a mixing unit 6 via a metering valve 7, a flow regulator 8 and a pipe 12. At the input to the mixing unit 6, the pipe 12 feeds the water to a misting nozzle 13 or other water mist generating means (for example, a simple orifice or restriction hole across which a pressure differential is maintained).

The system also includes a vessel or vessels 14 storing an inert gas such as nitrogen. Vessels 14 have an outlet connected via a means of pressure regulation 16 and/or a means of flow regulation 18 and a pipe 20 to another input of the mixing unit 6. The mixing unit 6 has an outlet pipe 22 which connects with a distribution pipe 24 terminating in spreader or distribution heads 26,28.

The water in the vessel 5 is pressurised by the gas within vessels 14, via an interconnection 30.

The nozzle 13 comprises any suitable form of nozzle for atomising the water to produce a water mist. Examples of suitable misting nozzles include single or multi-orifices, single or multi-orifice phase direct impingement nozzles, spiral insert nozzles and rotating disc nozzles. In principle, any standard water mist type nozzles can be used.

In use, and in response to detection of a fire or explosion, the vessels 5 and 14 are opened. Water from the vessel 5 and gas from the vessels 14 are fed under high pressure through pressure regulators 16 and 8, flow regulator 18 and metering valve 7, and thence along the pipe 12 and 20. The misting nozzle 13 produces a mist of water droplets which is injected into the mixing chamber 6.

In the mixing chamber 6, the water mist produced by the misting nozzle 13 is effectively added to the inert gas received via the pipe 20.. The resultant two-phase mixture (that is,

water mist droplets carried by the inert gas) exits the mixing chamber along the outlet pipe 22 and is carried at high velocity to a T-junction 23, and thence along the distribution pipe 24 to exit from the spreaders 26,28 into the volume to be protected (that is, the room, enclosure or other space where a fire or explosion is to be suppressed).

Tests have shown that the ratio between the mass flow rate of the water (M_w) to the misting nozzle 13 and the mass flow rate of the gas (M_g) along the pipe 20 to the mixing chamber 6 is a significant factor for determining the resultant droplet size distribution (DSD) in the mist which is discharged through the spreaders 26,28. If M_w is substantially constant while M_g rapidly decays (as the gas is discharged from the bottles 14), it is found that the median value of DSD increases during the discharge - which is not conducive to good extinguishing performance. It has been found that suitable adjustment of the ratio M_w/M_g can produce a more satisfactory DSD, in particular a value for DSD which is approximately constant for the entirety of the discharge.

In accordance with a feature of the system shown in Figure 1, the water in the vessel 5 is pressurised by the gas within the vessels 14, via the interconnection 30. Interconnection 30 is shown as connected separately to the two vessels 14. Instead, it could be connected to the pipe which they both feed. The metering valve 7 in the pipe 12 between the vessel 5 and the nozzle 13 enables the initial flow rate of the water in the pipe 12 (that is, the value of M_w) to be set. During discharge, the water is forced out of the vessel 5 by the gas pressure in the vessels 14 and passes through the metering valve 7 into the nozzle 13

where it is converted into a mist within the mixing chamber 6. At the same time, the gas is forced along the pipe 20 into the mixing chamber 6. As the gas pressure in the vessels 14 decays, there will clearly be a reduction in the value of M_w. At the same time, though, the reduced gas pressure will cause a reduction in the value of M_g in the pipe 20. Approximately, therefore, the ratio of M_w to M_g remains constant throughout the discharge. It is found that DSD remains substantially constant for the entirety of the discharge, and this in turn is found to produce improved fire extinguishing capabilities.

Figure 2 shows the results of a more detailed investigation into the values of M_w and M_g during discharge. Curve A shows the value of M_w, curve B shows the value of M_g and curve C shows the value of the ratio of M_w/M_g. Curve C shows that the ratio M_w/M_g is substantially constant for the majority of the discharge. However, there is a significant deviation from constancy during the early stages of the discharge. This suggests that an increase in the value of M_w during the early part of the discharge should be beneficial, because it will raise the value of the ratio M_w/M_g towards a constant value during this part of the discharge. This is found to increase the number of fine water droplets in the discharge and to improve the extinguishing capabilities.

In accordance with a feature of the system shown in Figure 1, therefore, the flow metering valve 7 is arranged to be dynamically adjustable during the discharge. For example, the metering valve 7 could be a motorised valve driven by an electrical stepper motor 9 under control of a control unit 10. The control unit 10 is responsive to an input dependent on

the decaying mass flow rate M_g in the pipe 20 during discharge, receiving an input from a suitable mass flow measuring device 11 (or alternatively receiving an input dependent on decaying pressure in the vessels 14). In a modification not shown, the control unit 10 is pre-programmed with values determined either via a flow prediction model or empirically. The control unit 10 thus energises the stepper motor 9 to achieve a desired value of the ratio M_w/M_g throughout the discharge in order to give a desired value for the DSD.

If a system of the type shown in Figure 1 is used to protect multiple areas (e.g. multiple rooms), there may be a single water cylinder fed by several gas cylinders. In the event of a fire, the number of gas cylinders activated (that is, opened) will depend on the number of areas or rooms where discharge is required. Thus, the metering valve 7 could be adjusted by the control unit 10 in dependence on the number of activated gas cylinders (and to tend to keep the ratio M_w/M_g constant).

Figure 3 shows a modification of the system of Figure 1 in which the metering valve 7 is directly controlled by the pressure in the vessels 14 (via a branch from the interconnection 30). Such a modification avoids the need for the motor 9, the control unit 10 and the measuring device 11. The characteristics of the valve 7 would be selected so that it was adjusted by the decaying gas pressure in such a way as to tend to keep the ratio M_w/M_g constant. In such an arrangement, M_g will be determined by the regulator 18 which will be sonically choked. M_w will be proportional to the square root of the pressure forcing the

water out of the vessel 5, that is, the pressure in the interconnection 30. M_w will be directly proportional to the effective size of the varying orifice in the metering valve 7. Thus, if the metering valve 7 is a pressure control proportioning water valve having an orifice size directly controlled by the gas pressure, this will tend to keep the ratio M_w/M_g constant.

Figure 4 shows a modified form of the system of Figure 1, in which the relative complexity of the continuously variable metering valve 7 of Figure 1 is avoided. As shown in Figure 4, the water from the vessel 5 can be fed to the nozzle 13 via either of two pipes 12A and 12B under control of a selector valve 29. In a modification not shown valve 29 comprises two separate selector valves. Pipe 12A incorporates a control orifice 32 having a relatively large open cross-section while pipe 12B incorporates a control orifice 34 having a relatively small open cross-section. In this way, therefore, the selector valve 29 can vary the value for M_w by selecting either the pipe 12A or the pipe 12B to feed the pressurised water to the nozzle 13.

For example, during the early part of discharge, the selector valve 29 will select pipe 12A so that the value for M_w is relatively high. After an initial period, when the pressure in the gas vessels 14 has decreased sufficiently, the selector valve 29 selects pipe 12B instead of 12A.

The selector valve 29 can be operated by an actuator 35 under control of a control unit 36.

The control unit 36 can simply measure the elapsed time since the beginning of discharge, and switch off pipe 12A and switch on pipe 12B instead after a fixed time has elapsed. In a modification (not shown), the control unit could measure the value of M_g in the pipe 20, or the pressure in the gas vessels 14, and switch from pipe 12A to pipe 12B when the measured value has decreased sufficiently.

If two separate selector valves are used, then during the early part of discharge the selector valves will select pipes 12A and 12B so that the combined M_w is relatively high. After an initial period, when the pressure in the gas vessels 14 has decreased sufficiently, the selector valves are set to select pipe 12B only.

Although only two control orifices are shown in Figure 4, allowing selection between a relatively large open cross-section and a relatively open cross-section, it will be understood that more than two such orifices could be provided, to give a greater number of changes in values of M_w.

It has been found that control of the ratio M_w/M_g is difficult at the end of the discharge, and large water droplets may occur which are considered to be undesirable. Therefore, the water flow from the vessel 5 may be stopped completely near the end of the discharge, to allow the remaining gas to remove any water residue present in the pipe network. The water flow could be switched off using the metering valve 7 of Figure 1 or the selector valve 29 of Figure 4 (which would have an appropriate intermediate setting). Instead, a

separate cut-off valve could be used.

When discharge is initiated, the pressure of the gas within the vessels 14, and the value of M_g, decay very rapidly. Tests on a particular installation have shown that 25% of the total mass of the gas has been discharged within two seconds of initiation of the discharge, and 50% of the total mass of the gas has been discharged within seven seconds. Clearly, therefore, it is important to use the first few seconds of discharge as effectively as possible. In accordance with a feature of the systems being described, therefore, vessel 5 can be opened before vessel 14. The pressure of the gas exerted on the water in the vessel 5 via the interconnection 30 will thus ensure that some water is present at the misting nozzle 13 when the gas valve is subsequently opened. This therefore helps to ensure that discharge of water mist through mixing chamber 6 takes place substantially instantaneously upon the opening of vessel 14, to take maximum advantage of the initial gas pressure. Furthermore, the initial presence of the water at the misting nozzle 13, when the flow regulator 18 is opened, helps to reduce problems (e.g. formation of ice) caused by the extremely low temperatures when the gas discharge starts.

It is also believed to be advantageous to ensure that an excess of water is present when discharge starts, to aid wetting of the pipe network. For example, a section 22A of the outlet pipe 22 (see Figure 1) can be sealed off at each of its ends by a burst disc and filled with water. When discharge starts, the pressure in the pipe 22 bursts the discs, making the trapped water available for pipe wetting.

Although the systems shown in Figures 1,2 and 4 pressurise the water in the vessel 5 using the gas pressure in the vessels 14 (via the interconnection 30), providing an advantageous tendency to a constant ratio of M_w/M_g, this method of pressurising the water is not essential. Instead, for example, the water in the vessel 5 could be pressurised in some other suitable way such as by means of a controllable pump. In such a case, a suitable control unit could be used to control the value of M_w, by varying the pump pressure, in such a way as to tend to keep the ratio M_w/M_g constant to achieve a desired DSD.

The liquid extinguishant used in the systems as so far described has been specified as water. However, instead, a suitable liquid chemical extinguishant can be used, preferably in the form of a chemical substance having low or zero oxygen depletion potential and a low environmental impact with a short atmospheric lifetime of preferably less than thirty days.

CLAIMS

1. A fire and explosion suppression system, comprising a source of pressurised liquid extinguishing agent, a source of a pressurised inert gas, mist producing means connected to receive a flow of the liquid extinguishing agent to produce a mist therefrom, mixing means for mixing the already-produced mist into a flow of the pressurised inert gas to produce a discharge in the form of a two-phase mixture comprising a suspension of droplets of the mist in the pressurised inert gas, and control means for controlling the ratio of the mass flow rate of the liquid extinguishing agent to the mass flow rate of the pressurised gas towards such a value as to tend to produce a desired droplet size distribution in and for substantially the duration of the discharge.

2. A system according to claim 1, in which the control means controls the value of the ratio towards a constant value.

3. A system according to claim 1 or 2, in which the control means includes means for pressurising the liquid extinguishing agent in dependence on the pressure of the inert gas.

4. A system according to claim 3, in which the pressurised inert gas is pressurised by being stored under pressure which thus reduces during the flow thereof and reduces the mass flow rate of the inert gas, and in which the control means includes means for applying the pressure of the stored inert gas to pressurise the liquid extinguishing agent

whereby the reducing applied pressure correspondingly reduces the mass flow rate of the liquid extinguishing agent.

5. A system according to any preceding claim, in which the control means includes controllable valve means for controlling the mass flow rate of the liquid extinguishing agent during the discharge.

6. A system according to claim 5, in which the valve means comprises a controllable metering valve means and the control means includes means for adjusting the metering valve means in dependence on the mass flow rate of the gas.

7. A system according to claim 5, in which the valve means comprises a controllable metering valve means and the control means includes means for adjusting the metering valve means in dependence on the pressure of the stored inert gas.

8. A system according to claim 5, in which the controllable valve means comprises a plurality of parallel flow paths for feeding the liquid extinguishing agent to the mist producing means and having respective flow orifices of different cross-sectional area, in combination with selection means for selecting any one or more of the flow paths.

9. A system according to any one of claims 1 to 3, in which the control means includes means for controlling the pressure of the pressurised liquid extinguishing agent.

10. A system according to claim 9, in which the control means includes a pump for pressurising the source of the liquid extinguishing agent.

11. A system according to claim 10, in which the control means includes means responsive to the mass flow rate of the inert gas for adjusting the pump to vary the pressure of the source of the liquid extinguishing agent.

12. A system according to any preceding claim, including means for initiating the flow of the liquid extinguishing agent before initiating the flow of the inert gas.

13. A system according to any preceding claim, in which the liquid extinguishing agent is water.

14. A system according to any one of claims 1 to 12, in which the liquid extinguishing agent is a chemical substance.

15. A fire and explosion suppression method, in which a mist of a liquid extinguishing agent is produced from a flow of the liquid extinguishing agent and is mixed into a flow of pressurised inert gas to produce a discharge in the form of a two-phase mixture comprising a suspension of droplets of the mist in the pressurised inert gas, including the step of controlling the ratio of the mass flow rate of the liquid extinguishing agent to the

mass flow rate of the pressurised gas towards such a value as to tend to produce a desired droplet size distribution in and for substantially the duration of the discharge.

16. A method according to claim 15, in which the value of the ratio is controlled towards a constant value.

17. A method according to claim 15 or 16, in which the controlling step includes the step of pressurising the liquid extinguishing agent in dependence on the pressure of the inert gas.

18. A method according to claim 17, in which the pressurised inert gas is pressurised by being stored under pressure which thus reduces during the flow thereof and reduces the mass flow rate of the inert gas, and in which the controlling step includes the step of applying the pressure of the stored inert gas to pressurise the liquid extinguishing agent whereby the reducing applied pressure correspondingly reduces the mass flow rate of the liquid extinguishing agent.

19. A method according to any one of claims 15 to 18, in which the controlling step includes the step of controlling the mass flow rate of the liquid extinguishing agent during the discharge.

20. A method according to claim 19, in which the mass flow rate of the liquid

extinguishing agent is adjusted in dependence on the mass flow rate of the gas.

21. A system according to claim 19, in which the mass flow rate of the liquid extinguishing agent is adjusted in dependence on the pressure of the stored inert gas.

22. A method according to any one of claims 15 to 17 in which the controlling step includes the step of controlling the pressure of the pressurised liquid extinguishing agent.

23. A method according to claim 22, in which the controlling step includes the step of varying the pressure of the liquid extinguishing agent in response to the mass flow rate of the inert gas.

24. A method according to any one of claims 15 to 23, including the step of initiating the flow of the liquid extinguishing agent before initiating the flow of the inert gas.

25. A method according to any one of claims 15 to 24, in which the liquid extinguishing agent is water.

26. A method according to any one of claims 15 to 24, in which the liquid extinguishing agent is a chemical substance.

27. A fire and explosion suppression system, substantially as described with reference

to Figure 1 of the accompanying drawings.

28. A fire and explosion suppression system, substantially as described with reference to Figure 3 of the accompanying drawings.

29. A fire and explosion suppression system, substantially as described with reference to Figure 4 of the accompanying drawings.

30. A fire and explosion suppression method, substantially as described with reference to Figures 1 and 2 of the accompanying drawings.

31. A fire and explosion suppression method, substantially as described with reference to Figures 2 and 3 of the accompanying drawings.

32. A fire and explosion suppression method, substantially as described with reference to Figures 2 and 4 of the accompanying drawings.

ABSTRACT (Figure 1)

A fire and explosion suppression system comprises a source (5) of high pressure water which is fed to a misting nozzle (13) at one input of a mixing unit (6), and a source (14) of high pressure inert gas, such as nitrogen, which is fed along a pipe (20) to another input of the mixing unit (6). Inside the mixing unit (6), water mist, in the form of an atomised mist of very small droplet size is mixed with the pressurised gas and exits the mixing unit (6) at high pressure and high velocity along a pipe (22) and is thence discharged through spreaders (26,28). The source (5) of the water is pressurised by a feed (30) from the source of pressurised inert gas. The mass flow rate of the water will therefore reduce as the pressure of the gas decays. This tends to maintain the ratio of the mass flow rate of the water to the mass flow rate of the gas constant. This is found to produce and maintain an advantageous distribution of droplet size in the discharged mist. A control unit (10) adjusts a metering valve (7) in dependence on the mass flow rate or the pressure of the gas in order to adjust the ratio as necessary to maintain its value constant.

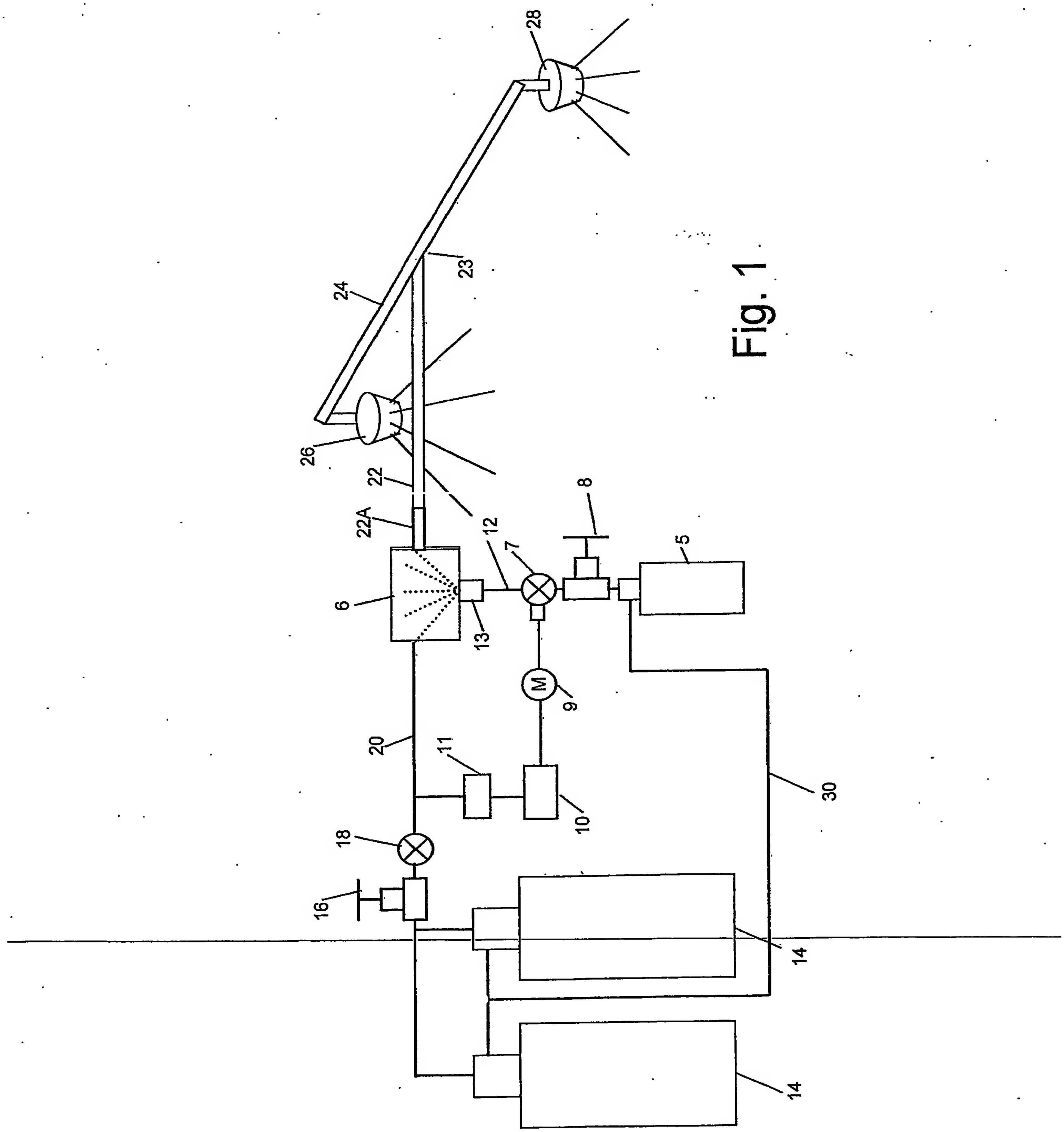

Fig. 1

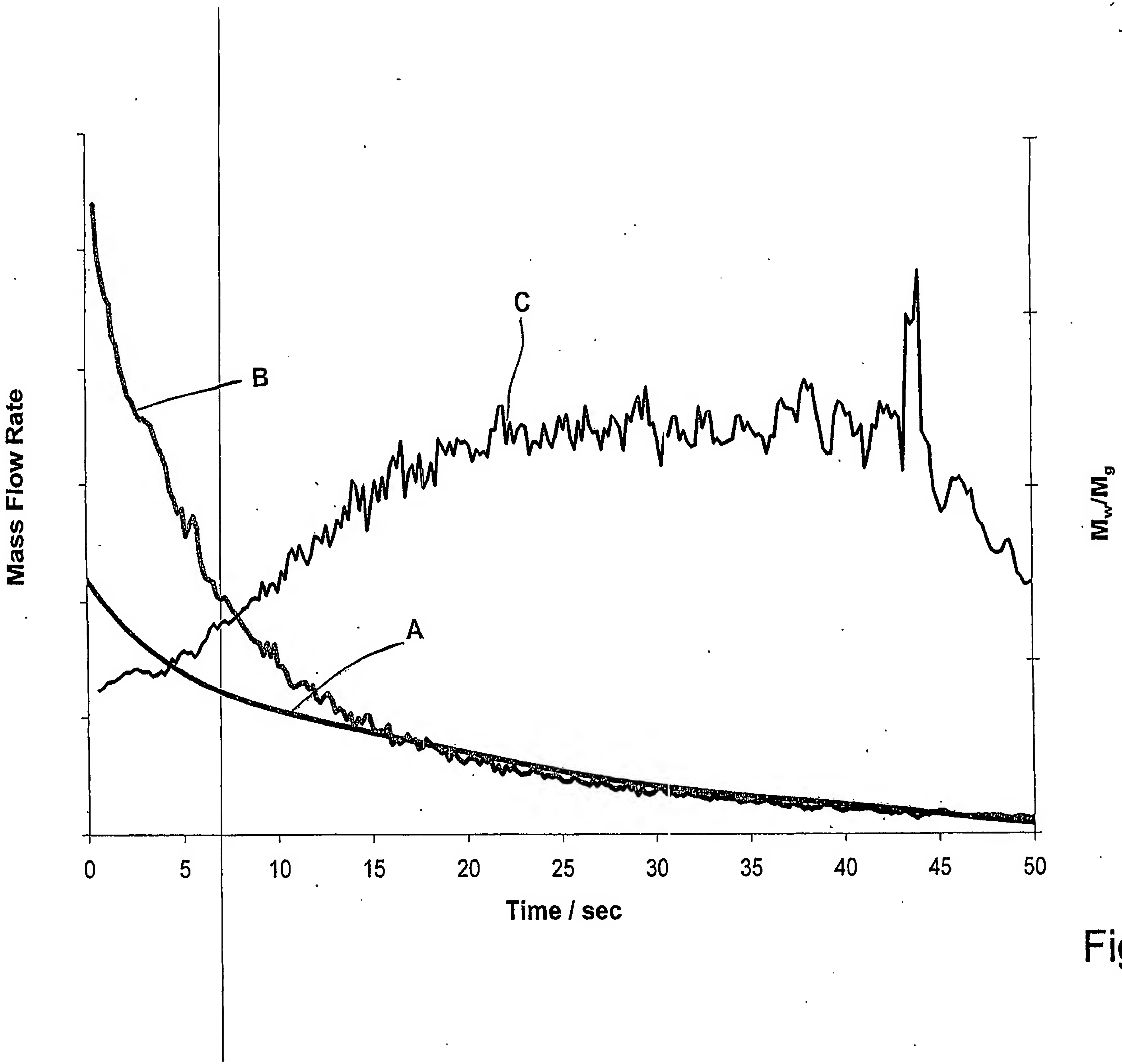

Fig. 2

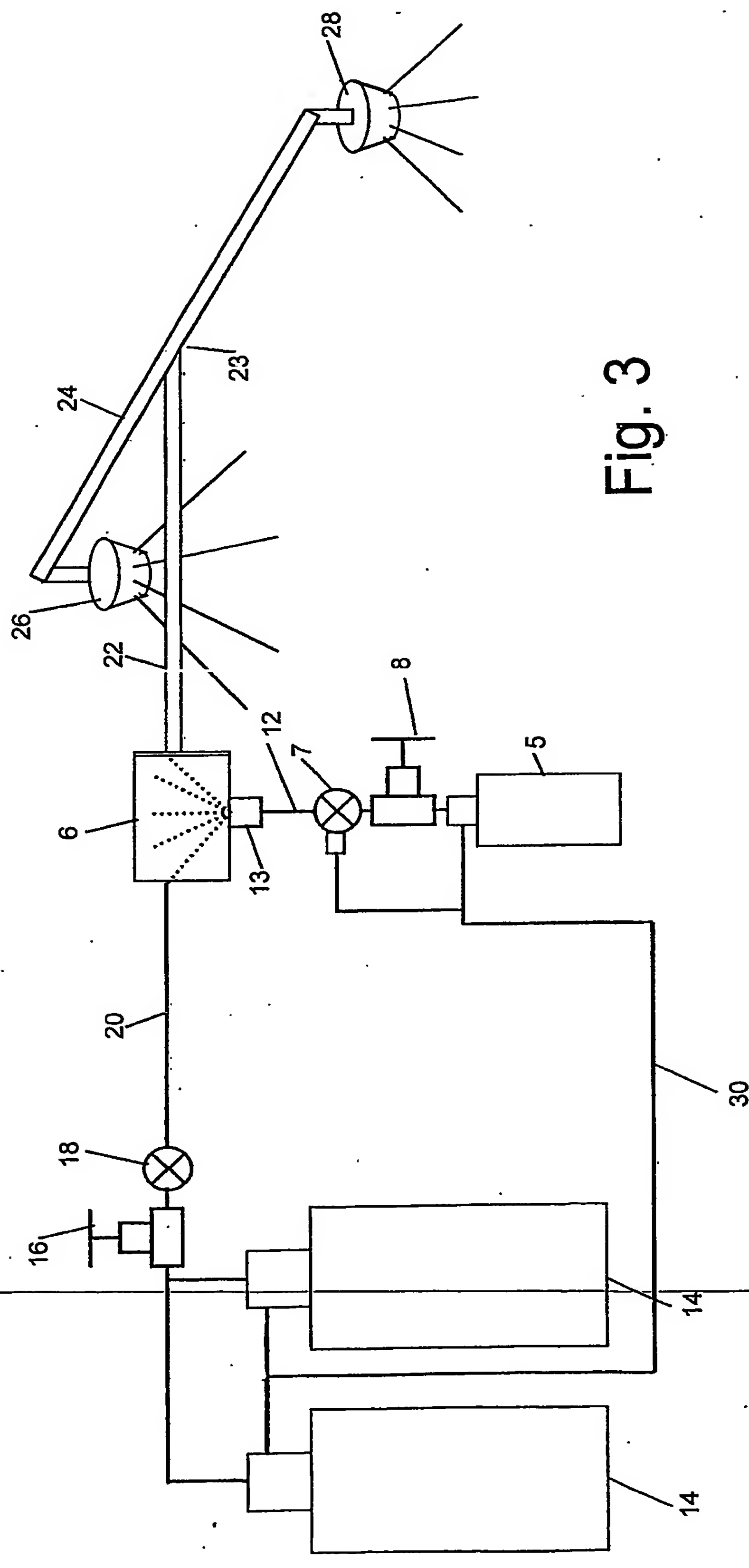

Fig. 3

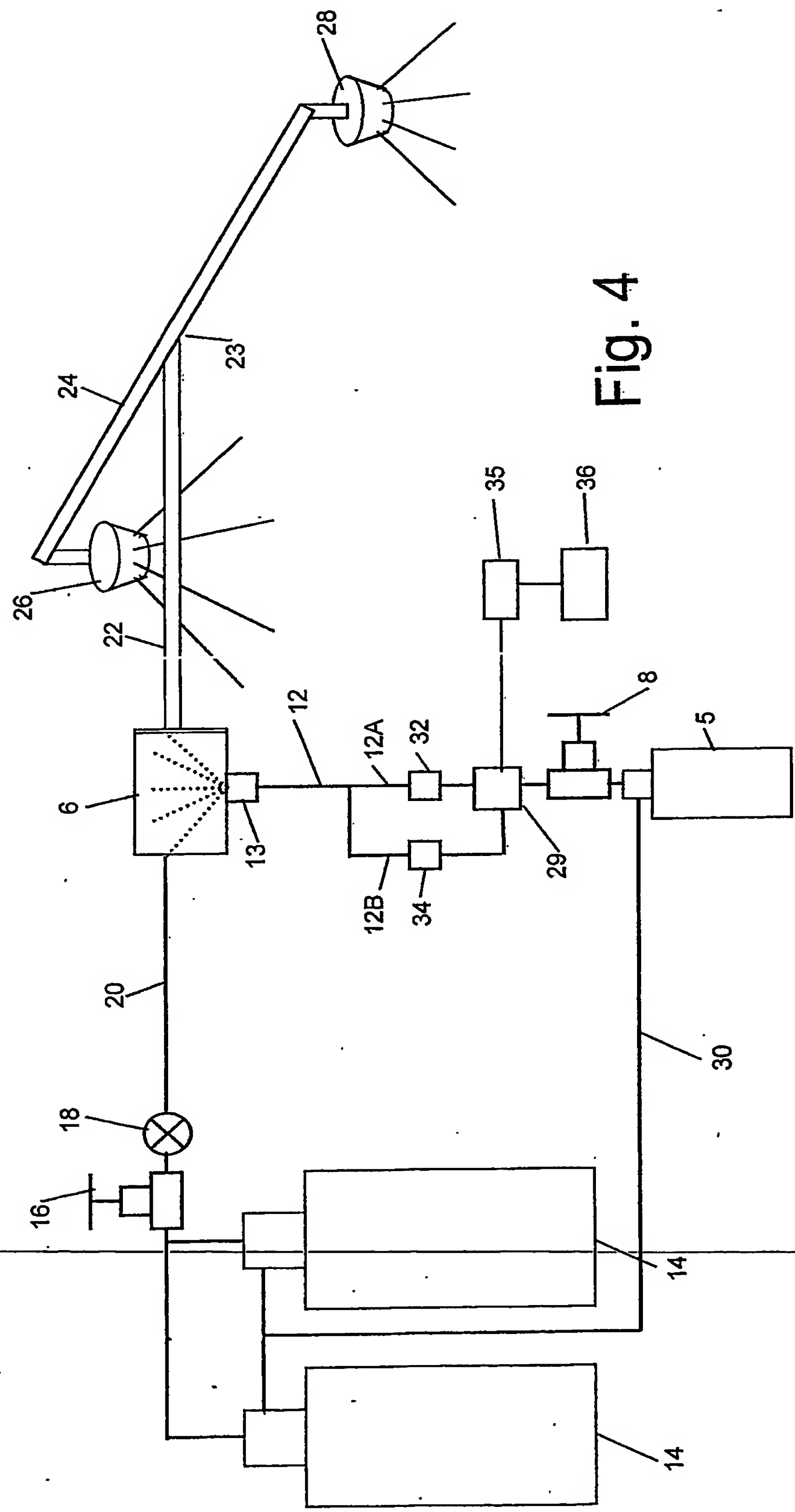

Fig. 4